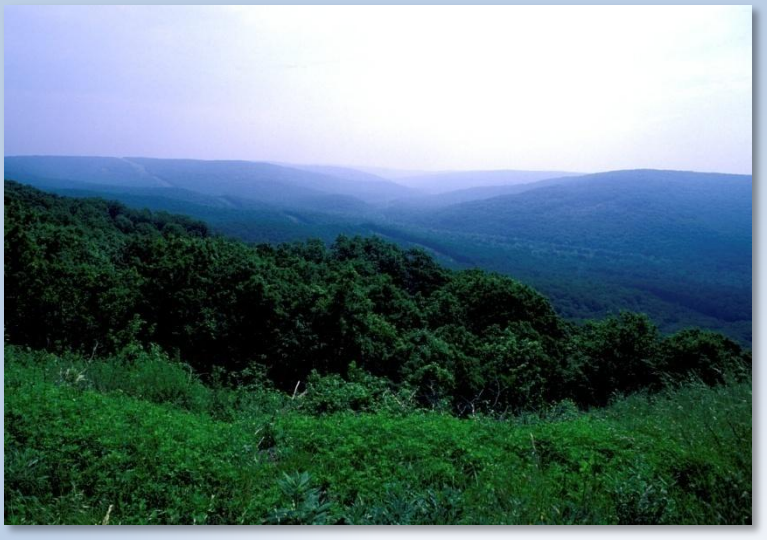
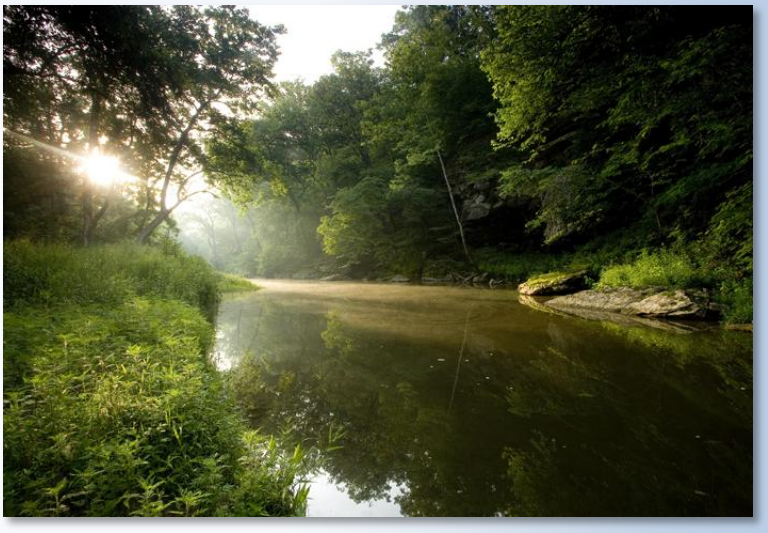


WATERSHED AND STREAM MANAGEMENT GUIDELINES for

Lands and Waters Managed by Missouri Department of Conservation





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Missouri Department of Conservation

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WATERSHED AND STREAM MANAGEMENT GUIDELINES

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WATERSHED AND STREAM MANAGEMENT GUIDELINES

Introduction



Missouri is a stream state. More than 110,000 miles of streams drain our diverse landscape. The characteristics of these streams are the product of the land surrounding them. Watersheds, which consist of uplands, floodplains, stream corridors, and stream channel networks, all interact to affect the quality of stream habitat and adjacent terrestrial communities. Natural characteristics of a watershed define the properties of a healthy stream. Unobstructed floodplains provide areas into which floodwaters may enter and reduce the erosive pressures on the rest of the stream system. Densely vegetated stream corridors contribute a multitude of direct benefits to the stream channel and buffer surrounding lands from the effects of floods. Stable channels balance the force of flowing water with the physical and vegetative conditions surrounding it. All these parts must be in balance for a healthy, stable hydrologic and biological system to operate. Thus, management of stream channels and stream banks cannot be considered separately from the entire watershed, including the uplands, floodplains and stream corridors.

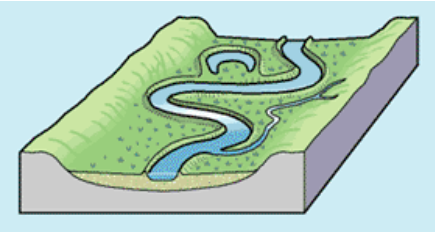
Key Assumptions and Facts

Department lands are a reservoir of species, and virtually all conservation lands require management to sustain habitat for native vegetation, fish, and wildlife. The purpose of these guidelines is to establish standards to protect, enhance, and manage the physical and biological components of stream systems on Department lands, positively affecting our water resources and maximizing the multiple benefits of streams and their associated terrestrial communities.

A key management assumption in managing Department lands and waters is that the maintenance of ecological functions is primary, and that maintaining ecological functioning is necessary for the long term survival and productivity of native flora and fauna. We also assume that management decisions for Department-owned and –managed lands are normally made through the interdivisional area planning process. However, some unplanned or emergency decisions have to be made and should be thoroughly considered by all disciplines affected. Failing to do so could result in unforeseen problems to streams and/or adjacent lands. This is especially true when surrounding lands are degraded. To compensate for that degradation, area managers must consider many things in managing the biotic integrity of the

conservation area and the surrounding area. Unless otherwise directed, an area manager should choose options that provide the most ecological functions to both terrestrial and aquatic communities, and in doing so, consult staff in other divisions.

Connectivity



Hydrologic systems are complex and dynamic, involving many interrelated components. Streams do not function in isolation from adjacent terrestrial landscapes; rather, the stream is determined by them. Stream channels are a product of the energy of flowing water (from channel gradient), sediment (from the watershed) and water quantity (from climate-watershed interactions). Altering these factors through upland, floodplain, corridor or channel activities can produce problems as the stream strives to achieve a new balance between energy, sediment and water quantity. For example, removal of large amounts of forest cover without the use of Best Management Practices (BMPs) in the watershed can result in faster runoff and more water and sediment delivered to a stream channel. The additional water in the channel can increase stream bank erosion and flooding, and the stream channel will widen, deepen, and meander more rapidly through erosion to accommodate the additional water and sediment. Conversely, conversion of an overgrazed watershed to a thick stand of grasses or forest decreases runoff, thus delivering less water and sediment to the stream channel. This often results in a narrower channel over time with lower erosion rates. Connectivity within the watershed-stream system may be lateral (alterations adjacent to the stream will impact it positively or negatively), or longitudinal (alterations can extend upstream, downstream, or both, often distant from the management site.) Terrestrial and aquatic managers should consider how management actions may affect energy, sediment, and water quantity; understand that actions can affect streams both upstream and downstream from a management site, and take steps to avoid or minimize the negative effects of management decisions. Managers should also remember that because streams are a product of runoff and sediment, and it is natural for them (as well as beneficial to fish and wildlife habitat) to meander and adjust in size and shape; locking a stream in a fixed position unnecessarily can cause a variety of problems, sometimes beyond the project site.

How To Use These Guidelines

The guidelines are divided into four sections corresponding to the four major stream system components: uplands, floodplains, stream corridors, and stream channels. Application of these guidelines will improve management of stream systems by improving the ability of area managers to recognize and address problems that may be detrimental to stream systems or one of their component parts by establishing criteria for desirable conditions.

Central to these guidelines is the definition of a stream. Earlier Department stream management

efforts relied on a stream appearing as a solid or dashed blue line on a 7.5-minute U.S. Geological Survey topographic map. However, that line often involved considerable judgment on the part of USGS mapmakers and was not based on physical characteristics other than those that could be seen on an aerial photo. Soils or valley topography are better indicators of a stream especially where flow is intermittent and permanent pools are not present. Therefore, these guidelines take a more physical approach. For the purposes of these guidelines, a stream is defined as any watercourse that has a defined bed and bank and possesses intermittent flow without permanent pools, intermittent flow with permanent pools, or permanent flow. Determining the presence of a stream often may take some field work and interpretation, especially in the headwaters.

These guidelines provide the framework for the management of Department lands and waters, but are not specifically designed to provide a cookbook on all the steps necessary to get there. Department-owned and –managed areas represent habitats for a wide variety of plants and animals, and a multi-disciplinary approach is required to optimize management success. Fish, forest, and wildlife management on Department lands should support abundant fish and wildlife populations, and demonstrate good terrestrial and aquatic stewardship that private landowners can copy on their own property. Overall management direction is detailed in area plans, and managers are urged to incorporate these guidelines into area plans when they are written. However, not all management is according to plan. Sudden degradation of adjacent private lands (e.g., a new CAFO with land application of lagoon effluent), any emergency (e.g., flood or tornado damage to a conservation area) or additional management steps (e.g., implementation of a statewide management strategy for which the conservation area may be in a focus area) taken on a conservation area should be planned and carried out with these guidelines in mind. While these guidelines are specific for Department-owned and –managed areas, they may also be applicable to the management of adjacent private lands. Flexibility on management standards when working with private landowners may sometimes be needed in order to encourage participation and improve habitat quality, especially in riparian areas. However, wherever possible, we should strive to manage our lands better than what is found on private lands so that we set a good example and minimize the problems that come with recommending practices that are beyond those we routinely install on our areas. Private land resource management progress often occurs in increments, and Department staff are encouraged to work with landowners, using appropriate financial incentives (e.g., providing livestock watering outside of riparian zones) to improve conditions that affect Department areas, as well as lands and waters elsewhere.

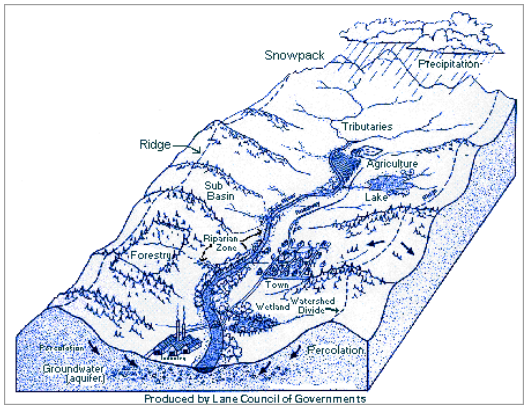
The guidelines that follow are those management actions that will apply to most area management situations. However, flexibility has been built into these guidelines to provide Department managers the ability to address unique management opportunities or site-specific conditions for which these guidelines may not be totally appropriate. The central features of these guidelines are the functions attributed to watersheds, floodplains, stream corridors and stream channels, so articulating and agreeing on a desired future condition for management on conservation areas in terms of habitat structure, species composition, and ecological functioning for both terrestrial and aquatic systems is critical to designing appropriate management

strategies. Alternative management strategies are encouraged to address specific area needs, but should be planned and carried out in such a manner that those functions are improved or maintained.

Many of our management techniques require an understanding of the trade-offs between benefits and costs to other resources. For example, management of terrestrial systems impact receiving aquatic systems, but careful planning and management by multiple disciplines in these situations is expected to minimize or eliminate negative impacts. Balancing benefits and costs requires an understanding of spatial and temporal scale (short term and long term) changes to the terrestrial/aquatic system. These guidelines are an attempt to balance all of our management needs in this context; users implementing management directions that follow these guidelines can assume that competing resource needs are taken into consideration.

Managing divisions must work together towards common Department goals and objectives, and integrating our approaches is essential to implementing our initiatives. In most cases, management approaches on Department lands will be designed and implemented in collaboration with Wildlife, Fisheries, and Forestry staff. Private Land Services, Design and Development, Policy Coordination, and Resource Science staff should also be consulted as appropriate. Department policy and state and federal law also dictate that appropriate permits are obtained and information reviewed prior to working in or near streams. Permits include, but are not limited to, Heritage database review, cultural resources surveys, Section 404 (dredge and fill) permits, Section 401 water quality certification, and Section 7 species of conservation concern consideration. Some activities (e.g., certain silvicultural practices or minor bank stabilization projects) may be exempt from some permit requirements. Staff with responsibility for project oversight should be mindful of permitting requirements, work towards meeting these legal obligations for the Department and check first with Policy Coordination Unit for help.

Watershed Guidelines



A watershed is the region or area bounded by a water divide and draining to a watercourse. Watersheds can vary from a few acres to thousands of square miles. For these guidelines, a watershed is defined as the total land area that contributes runoff to a body of water. This includes surface runoff and groundwater discharge.

Function: Watershed conditions influence stream hydrology, groundwater recharge, water quantity and water quality. Healthy watersheds trap pollutants, soil particles and excess runoff. Excessive watershed runoff increases water quantity, reduces water quality, contributes to an increase in stream channel size and delivers excess sediment to the stream generally resulting in stream bank

erosion and stream channel aggradation (filling). Watersheds also provide terrestrial habitat for migratory and resident wildlife with native vegetation, high plant diversity including both woody and herbaceous species, and an abundance of snag and cavity trees; provide corridors for wildlife movement and dispersal of plant species, and provide critical habitat for many Missouri species of conservation concern.

Guidelines:

1. Map watershed boundaries for all streams flowing through Department areas.

2. Inventory Department areas for gully, sheet, and rill erosion. Soil erosion plan development and implementation is contained in the current Policies and Guidelines for Area Resource Management, Soil and Water Conservation Plans (http://intranet/Documents/12817.pdf.) Excessive erosion, especially gullies, deliver sediment directly to the stream and should be a high priority for remediation. In addition, more sophisticated methods of watershed assessments (e.g., EPA's Watershed Assessment of River Stability and Sediment Supply, or WARSS) may be used to provide a more detailed analysis of contributing problems.

3. Develop a soil conservation plan, using the USDA Natural Resources Conservation Service if necessary, that will keep soil erosion within the watershed at or below T (the soil replacement level). The soil conservation plan should apply to forest and grassland areas as well as cropland. Land use or management activities should be evaluated for impacts to stream health and designed to keep soil erosion at or below T. Other land uses should be applied if this is not possible. The importance of this guideline cannot be understated; MDC is the biggest single farmer in the entire state and we must set the best example of soil and water conservation in conjunction with agricultural practices.

4. Identify obvious runoff and erosion problems on adjacent lands. Where feasible, develop measures to prevent or slow sediment from traveling across the Department area and reaching the stream channel. In addition, identify and develop measures to prevent problems that may be contributing to overall stream instability (e.g., correcting a large gully on an upstream landowner that is contributing large amounts of gravel to the stream as it flows through a Conservation Area).

5. In watersheds where forest is predominant, timber harvest is a valuable land management tool and the potential disturbances associated with it are usually temporary. However, care must be taken to insure that the temporary mobilization of sediment from timber cutting activities is minimized by:
    - ❒ Using appropriate erosion control methods during active logging operations (see Missouri Watershed Protection Practices: Management Guidelines for Maintaining Forested Watersheds to Protect Streams MDC, 2006; http://mdc4.mdc.mo.gov/documents/441.pdf).

- ❒ Using appropriately-sized buffer strips (see Stream Corridors, Vegetative Management) between harvest areas and drainages leading to streams until the harvest area has recovered
- ❒ Using appropriate methods for post-harvest closure, stabilization and revegetation of logging operations

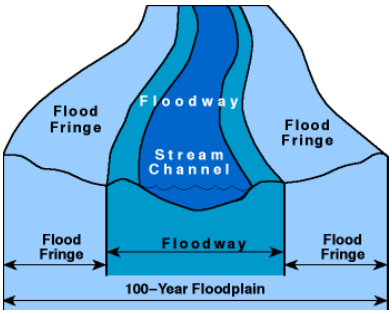
6. In watersheds where prairie and grasslands are predominant, grassland management practices like grazing, haying, fire, patch-burn grazing, or a combination of the above can be effective management tools for prairie wildlife and plants. When planned and executed at the right time and location, these management techniques can be carried out with only temporary disturbances, especially when the following are incorporated into management planning:
   - ❒ Controlled grazing should be closely monitored to insure that the grazing period, stocking rate, and grazing system are closely matched to the vegetation and soil type. Grazing should be limited to non-forested grassland systems where soil disturbances are minimized. Excluding cattle from streams is important to avoid negative stream impacts; if cattle cannot be excluded from streams and stream corridors, an interdisciplinary team should come to consensus on how to trade off adverse impacts (see Stream Corridors--Vegetation Management.)
   - ❒ Prescribed burning is crucial to the restoration and maintenance of many terrestrial natural communities, including prairies, savannas, woodlands, glades, fens, and marshes. Prescribed burning may temporarily remove the sediment filtering and soil stabilizing functions necessary for erosion control; however, properly applied prescribed burning, by creating more vigorous and abundant ground cover of forbs and grasses, may also lead to increased infiltration rates and decreased soil erosion and runoff through time as part of a restoration process on fire-adapted communities. Managers must be sensitive to soil erosion and the sediment filtering capability of unburned vegetation especially in the upper reaches of watersheds. Therefore, to the extent possible, prescribed burning should be carried out when the vegetative response to fire is the fastest, or when the duration of soil exposure to the elements is the shortest. If this is not possible, use of appropriately sized, unburned buffer strips between burn areas and stream channels is recommended to minimize these impacts.

7. Construction activities in watersheds can be conducted with minimal and temporary impacts to streams provided that the dislodging and mobilization of sediment is minimized. Appropriate erosion control methods, such as temporary retention basins, gully stabilization structures, silt fences, and vegetated buffer strips, must be considered on all construction projects. If installed, these should be properly maintained.

8. Watershed management activities should be carried out on Department areas such that they do not significantly impact instream flows or alter instream habitats. Fisheries policy on Instream Flow and Department guidance on the maintenance of ecological stream flows should be followed.

9. Impoundment construction on Department areas should be planned and carried out according to Fisheries Division's Best Management Practices for Water Quality and Stream Channel Protection when Planning Permanent Impoundments on Ephemeral or Intermittent Streams (http://intranet/Documents/18362.pdf). Planned fish stocking of these impoundments should consider the impacts of downstream transport of predatory fishes on downstream fish communities.

Floodplain Guidelines



A floodplain is the relatively flat land surface adjacent to a stream channel that is formed by erosion and sediment deposition during floods. Floodplains can be inundated annually or only during large, infrequent floods, and comprise the above-bank area where floodwater enters to dissipate energy during high flows. Thus, floodplains are characterized by soils and vegetation that developed under the influence of flooding. Floodplains can be geographically located from floodplain maps available from agencies involved in floodplain management or enforcement, or can be identified by characteristic soils and vegetation where such maps are not available.

Function: Floodplains have several major functions:

1. The floodplain transports and stores water during flood events. This reduces the velocity and erosive capability of floodwaters and reduces the impacts of flood events on downstream areas. Floodplain vegetation can also help reduce the velocity of floodwater.

2. Floodplain vegetation filters and traps sediments and nutrients during storm events that would otherwise reach the stream and cause deposition, stream bed aggradation and non-point pollution problems.

3. Groundwater recharge following major storm events is a function of floodplains. Rainwater is retained in floodplain wetlands and percolates underground. Depending on soils and local geology, this groundwater can augment base flows during drier periods.

4. Floodplains contain wetland habitats that are heavily used by a number of animals, including fish and other aquatic life, waterfowl, shorebirds, reptiles and amphibians, and aquatic mammals

5. Floodplains provide terrestrial habitat for migratory and resident wildlife with native vegetation, high plant diversity including both woody and herbaceous species, and an abundance of snag and cavity trees; provide corridors for wildlife movement and dispersal of plant species, and provide critical habitat for many Missouri species of special concern.

Historically, floodplain wetland communities were dynamic. Floods and natural stream meanders created new wetlands that gradually succeeded to terrestrial communities. That process generally stopped when streams were channelized, reservoirs were constructed and meandering was prevented to protect bridges, cropland and property lines. Additionally, upland erosion, stream bank erosion and stream channel degradation have produced stream sediment loads that are filling wetlands and destroying wetland vegetation. Consequently, diverse, natural wetland habitats are now rare. Formerly created and maintained through natural processes, these habitats are now usually (although not exclusively) provided through active management and construction. Wetland installation and management techniques are covered in the MDC Wetland Plan, Missouri Wetlands and Their Management (http://www.mdc.mo.gov/landown/wetland/wetmng/aknow.htm), and the draft Guidelines for Promoting Fishery Resource Benefits in Missouri Wetlands (http://intranet/Documents/18363.pdf). Floodplain guidelines in this document are not intended to describe how to install or manage wetlands but will assist in locating proposed wetlands in sites that promote floodplain, riparian and stream channel stability.

Guidelines

Management activities in floodplains that may affect floodplain functions include construction and maintenance of facilities and vegetation management.

Construction Projects

The design and construction of habitat and public use facilities in floodplains must take into account flood flow alterations, reductions in floodwater storage capacity and stream bank erosion. Major facilities routinely constructed in floodplains include levees, roads, boat ramps, parking lots, privies, pumps and water control structures. The following general guidelines apply to the construction of facilities in floodplains:

1. Construction projects in floodplains shall comply with appropriate federal, state and/or local floodplain regulations or ordinances.

2. Depending on the height, location and length, levees for wetland management can reduce floodplain water storage capacity and increase water velocities and flood durations in stream channels. New levee and/or other earthwork construction should be designed to complement the natural stability and dynamic tendencies of the stream channel and minimize damage to stream banks, stream beds and floodplains. Existing levees should also be evaluated based on their impacts to the natural stability and dynamic tendencies of the stream channel. Those that are damaging streams should be redesigned (lowered, breached, relocated away from the stream channel, etc.).

3. Prevent gully erosion into the stream.

4. Tributary, high flow and upland drainage channels that carry flood flows are part of the receiving stream's hydraulic regime and should be preserved. Do not block, constrict,

excavate, or devegetate high flow or upland drainage channels. Development that impacts these channels should consider the effect on the total hydraulic system.

5. Minimize floodplain scour by designing structures to minimize erosion. This may include:
   - ❒ constructing temporary or service roads perpendicular to flood flows
   - ❒ placing adequately-sized culverts in bottomland road crossings
   - ❒ elevating public use roads only enough to facilitate drainage and drying
   - ❒ protecting the shoulders and slopes of roads against erosion
   - ❒ avoiding filling, blocking or otherwise obstructing high flow or upland flow channels, or changing flow patterns that could increase erosion

6. Facilities such as boat ramps, parking lots, privies, pumps and water control facilities should be located to avoid floodplain scour and/or constriction problems during and after construction.

Vegetation Management

The primary emphasis of vegetation management in floodplains should be to reestablish and maintain native riparian wetland vegetative communities associated with bottomland forests, marshes, blue holes, oxbows, sloughs and lowland prairies. Floodplain management practices to maintain diverse native plant communities may include burning, periodic cropping and silvicultural practices. The following general guidelines apply to vegetation management in floodplains:

1. Unless otherwise directed by an area plan, emphasize the maintenance and restoration of native communities indigenous to the floodplain.

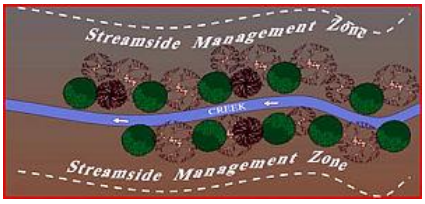
2. Design vegetation management to eliminate potential floodplain scour problems. Reduce scour erosion in large bottomland crop fields by establishing permanent woody vegetation or native grasses in strips perpendicular to flood flows.

3. In floodplains where unacceptable scour is anticipated, consider confining crop fields to higher-elevation floodplains that are infrequently flooded.

4. Follow stream corridor vegetation management guidelines for high flow channels.

5. It is important to match the vegetation to be reestablished with the soil type of the area.

Stream Corridor Guidelines



A stream corridor is a designated management zone beginning at the top of the stream bank and extending away from the stream. Also known as the riparian area or streamside

management zone, the stream corridor serves important stream functions including sediment trapping, use and storage of excessive nutrients, shading of the stream, slowing the velocity of flood waters, bank stability, natural wetland development and delivery of organic matter to the stream. High flow channels adjacent to streams are also hydraulically important to the stream channel, and should be included in stream corridor management efforts.

Function: Stream corridors provide many functions attributable to floodplains in general as well as the following unique functions:

1. Protection of water quality by reducing erosion of stream banks and adjacent high flow areas; providing sites for the filtering and deposition of sediments and debris; and capturing the surface and subsurface flow of excessive nutrients and contaminants thereby reducing inputs to the stream.

2. Moderation of stream water temperature by shading from trees.

3. Providing aquatic habitat systems with a diversity of organic material (hardwood leaf litter, grassland residue) as energy sources for aquatic food chains and large woody debris as instream habitat for fish and other aquatic fauna.

4. Slowing velocity of out-of-bank flows and mitigating accelerated meander rates with the hydraulic roughness provided by vegetation.

5. Providing terrestrial habitat for migratory and resident wildlife with native vegetation, high plant diversity including woody and herbaceous species, an abundance of snag and cavity trees, corridors for wildlife movement and dispersal of plant species, and critical habitat for many Missouri species of conservation concern.

6. Production of natural resource products (wood products, grassland forage for wildlife, recreation, etc.) at a sustainable level compatible with other corridor functions and benefits.

Guidelines:

"Stream corridor" is used in a generic sense to include lands adjacent to high flow channels as well as those along the stream itself. Unless otherwise indicated, the following guidelines apply to both:

Corridor Designation and Streamside Management Zone Width

1. Clearly designate stream corridors on all streams as well as on high flow channels in the floodplain. Identify high flow channels from on-site inspections, recent aerial photographs, or USGS topographic maps during the process of defining stream corridors.

2. Consider extending stream corridor designations farther up small, upland drainages (not meeting the stream definition) to link forest fragments, provide a travel corridor for wildlife between disjunct blocks of terrestrial habitat, and/or to mitigate runoff and erosional issues.

3. Width of the stream corridor is critical in ensuring that the potential functions and benefits of the stream corridor are realized. Consider stream size, stream slope, drainage area, need for filtering runoff, stability of stream reach, slope of adjacent areas, life history requirements of resident species, potential for stream bank erosion and channel meander in determining corridor width. In many cases, a stream corridor can be based on the floodplain/natural community. The natural community area of the stream corridor can be determined by biotic community type or the flood plain/alluvial soil area adjacent to the stream. The stream corridor width could be contiguous with the natural community area adjacent to the stream, provided that minimum widths were met.

4. Establish a stream corridor width in non-forested areas with a minimum of 50 feet from the top of the bank on each side for stream orders one and two (intermittent streams with or without permanent pools). Other width minimums can be considered on a case-by-case basis, provided that the stream corridor functions are met.

5. Establish a stream corridor width in non-forested areas with a minimum of 100 feet from the top of the bank on each side for 3rd order streams and larger. Wider corridor widths may be necessary on large or unstable streams, and other width minimums can be considered on a case-by-case basis, provided that the stream corridor functions are met.

6. In forested areas along stream order two, *or* in smaller streams that have permanent pools or continuous flow of water, establish a Streamside Management Zone (SMZ) within the stream corridor. During silvicultural management activities use Streamside Management Zone (SMZ) rules and widths as discussed in the Missouri Watershed Protection Practices: Management Guidelines for Maintaining Forested Watersheds to Protect Streams MDC, 2006 (http://mdc4.mdc.mo.gov/documents/ 441.pdf), but in no case should the SMZ be less than 50 feet from the top of the bank on each side of the stream. Other width minimums can be considered on a case-by-case basis, provided that the stream corridor functions are met.

7. In forested streams 3rd order or larger, a minimum of 100 feet from the top of the bank on each side is needed for the width designation of the riparian corridor. The SMZ width during silvicultural activities should also be 100 feet. Other width minimums can be considered on a case-by-case basis, provided that the stream corridor functions are met.

8. Expand the corridor width to include areas disturbed by high flows, active gullies and along stream reaches with actively eroding banks or to accommodate long term stream channel changes or meanders.

9. Expand the corridor width to include the balance of soil types, forest stands or other native vegetation types that fall partially within the corridor. In many cases, these may be natural communities (i.e., unique plant or animal communities or habitats, spring branches, caves, fens, etc.) otherwise identified for protection or management. Managers may identify soil types, forest stands or other native vegetative communities exceeding the minimum corridor widths. Managers can choose to designate entire stands as stream corridors and manage them according to corridor management guidelines. Specific situations where this option may be practiced include:
    - ❒ Natural communities on steep slopes that descend directly to the edge of the stream bank.
    - ❒ Natural communities on the floodplain that do not differ from the corridor and can be effectively managed under corridor management guidelines.
    - ❒ Locations where native community management is an objective and corridors must be expanded to accommodate an entire community.

10. Expand the corridor width to benefit fish and wildlife. Examples where expansion for this purpose would be desirable include:
    - ❒ An area lacking bottomland forest habitat.
    - ❒ A relatively narrow corridor along a small stream that connects two large tracts of forest.
    - ❒ An area with a habitat emphasis on forest interior wildlife or species of conservation concern.

Vegetation Management

1. Manage stream corridors and high flow channels for natural forest communities. However, where other native communities (wetland, prairie, savanna, glade) historically occurred, these communities may be restored provided that their establishment does not cause stream instability and continues to provide necessary stream corridor functions. Consult with local Fisheries Management Biologists and/or Stream Unit staff to make this distinction. It is also important to ensure native community restorations consider stream corridor functions in regard to aquatic and terrestrial species and the integration of these needs should be an interdisciplinary decision.

2. Revegetate sites designated for conversion to native vegetation by planting or succession. Plantings should include a mix of native species that would naturally occupy the site. To the extent possible, planting patterns should mimic characteristics of natural sites; straight-line and parallel plantings should be avoided, and a patch work planting at right angles to the stream flow to create hydraulic roughness and erosion control should be considered.
    - ❒ Manage for native, perennial vegetation to provide the functions of streamside filters and to encourage erosion-resistant root systems.
    - ❒ Carefully evaluate the use of herbicides, mowing, grazing and haying, and apply these practices in a manner that minimizes or eliminates impacts to stream channels and water quality.

3. Grassland managers must be sensitive to soil erosion and the sediment filtering capability of unburned vegetation especially in the upper reaches of watersheds. Manage non-forested stream corridors according to these guidelines:
    - ❒ Manage for native, perennial vegetation to provide the functions of streamside filters and to encourage erosion-resistant root systems.
    - ❒ Carefully evaluate the use of herbicides, mowing, grazing and haying, and apply these practices in a manner that minimizes or eliminates impacts to stream channels and water quality.
    - ❒ Excluding cattle from riparian zones is important and fencing should be used. When determining the extent to which cattle may have access to some or all of a defined stream channel, a field inspection is required. Managers should design grazing systems to minimize the concentration of cattle and lessen compaction and erosion. Fencing most of the riparian corridor while allowing livestock access at stable access areas where livestock watering, crossing, etc. are needed may be considered. Streams with smaller areas of drainage may also require fencing due to the sensitivity of the aquatic system and any exceptions should be site-specific, interdisciplinary and reflect a reasonable balance between critical aquatic and terrestrial species needs.
    - ❒ Riparian zones can offer opportunities as firebreaks, but the need for residual vegetation to filter sediments and reduce riparian corridor and floodplain scour should be considered. When possible, plan prescribed burning in non-wooded corridors to avoid months where high water can be expected so as not to reduce the hydraulic roughness of near-channel areas.
    - ❒ Do not plant agricultural crops in stream corridors.
    - ❒ Invasive species should be eliminated to the extent practical.
    - ❒ For streams in prairie areas, woody vegetation removal should be limited to the removal of trees not associated with prairie landscapes and only in areas where the removal of these trees does not have a negative impact on the stability of the stream channel. Small woody shrubs common in prairie landscapes should not be removed.
    - ❒ For streams in prairie areas where riparian management includes woody vegetation removal, remove all tree tops from the stream channel, or areas where they are susceptible to being washed into the channel to avoid creating channel log jams.

4. Management of forested stream corridors, including silvicultural practices, should include the following considerations:
    - ❒ Maintain a minimum of C-level stocking (all growing stock considered) in streamside management zones (see Missouri Watershed Protection Practices: Management Guidelines for Maintaining Forested Watersheds to Protect Streams MDC, 2006; http://mdc4.mdc.mo.gov/documents/441.pdf); managers are encouraged to expand this area as part of the managed corridor. C-level is the minimum to classify a stand as adequately stocked and still maintain a density of woody vegetation that fulfills the corridor functions listed previously. Stockings

lower than C-level should be considered infrequent exceptions, but can be undertaken when justified to address a specific problem such as erosion caused by high energy flows or the occasional need to regenerate segments of the riverfront forest community when a regeneration plan is developed with a stream biologist.

- ❒ Maintain a diversity of native tree species within the corridor to benefit wildlife and contribute a diversity of leaf litter into the stream. Trees should be native species and adapted to the site. Management should not emphasize a single species, or a limited number of economically valuable species, to the detriment of overall species diversity. However, occasionally emphasizing a particular species or forest type for its important habitat value would be acceptable, provided stream corridor functions are met.
- ❒ Do not graze designated forested stream corridors.
- ❒ When possible, avoid prescribed burning in wooded corridors during April and May to avoid reducing hydraulic roughness and minimize tree mortality. Unless necessary, don't headfire through riparian corridors. Burn intensity in wooded riparian corridors is normally low; prescribed burn ignition strategies that allow for burns to naturally extinguish as the flaming front enters a riparian corridor should be undertaken.
- ❒ Invasive species should be eliminated to the extent practical.
- ❒ Maintain or manage stands with large trees closer (approximately 50 feet) to the stream to provide shade and to establish an extensive root system for bank stability and provide large woody debris for fish and invertebrate habitat. Leave "hydraulically-important" trees that armor or protect specific stream corridor areas.
- ❒ Maintain abundant snag and cavity trees to provide habitat for the many wildlife species that use stream corridors. Follow the snag and cavity tree objectives recommended for wooded watercourses in the publication, Management of Snag and Cavity Trees in Missouri (http://mdc4.mdc.mo.gov/Documents/279.pdf).

5. Harvesting can be a useful tool in forested stream corridors to maintain or create a desired management condition or to improve the stream corridor capability to function in a specific manner and benefit the stream. The activities and potential disturbances associated with harvesting are temporary. Impacts within the corridor should be eliminated or minimized by harvesting carefully with the following guidelines.
   - ❒ Locate log decks, log landings and portable sawmills on stable, adequately drained soils outside of any stream channel, the designated stream corridor and active floodplain, away from any body of water or wetland.
   - ❒ Locate forest harvest roads and skid trails outside of all stream channels and corridors except in situations where topography, ownership boundaries or other unusual obstacles or circumstances cause a need for the road or trail to be located within the corridor. Such intrusions should be minimized and the road or trail retired in a stabilized condition immediately after use.
   - ❒ Where temporary stream crossings or fords are essential to facilitate harvesting, plan the harvest system to minimize the number of crossing locations. Locate crossings at riffles or other level, shallow, and firm stream bed locations.

- ❒ All approaches to temporary stream crossing locations should be at right angles to the stream and at the minimum slope needed to serve the harvesting operation. Bare soil on approaches and edges of bank cuts should be stabilized with coarse rock or large stones to prevent rutting of approaches and erosion of bare cut areas.
- ❒ Soft streambeds at stream crossing locations should be hardened with coarse rock placed at the original stream bed level.
- ❒ When temporary culverts or bridges are used they must be properly sized, should not alter the flow of stream water, and must allow passage of aquatic organisms; in most cases, a structure that causes a velocity at normal flow of no more than 3 feet per second meets these criteria. Temporary crossings of logs and brush topped with soil should be avoided.
- ❒ Timber harvested from the stream corridor should be cabled out or skidded at right angles to the stream. Avoid the operation of wheeled or tracked vehicles within 25 feet of the stream bank.
- ❒ To the extent possible, fell trees to direct the tops away from any stream channel. When trees are felled into an order 2 or larger stream, or in a stream that has permanent pools or a continuous flow of water, remove all tree tops from the stream channel, or areas where they are susceptible to being washed into the channel to avoid creating channel log jams.
- ❒ Avoid creating large areas of bare mineral soil except when creating seeding conditions for establishment of a streamside forest.
- ❒ Harvesting equipment should not be operated in any stream channels except at designated crossing locations to avoid damage to the stream bed and to minimize the opportunities for fuel, oil and other toxic substances to enter the stream. Equipment maintenance should be performed outside of stream corridors, all lubricants and fuels should be stored outside the 100-year floodplain, and all waste disposed of in a responsible manner outside the stream corridor.

6. It is important to match the vegetation to be reestablished with the soil type of the area.

Construction Activities

1. Locate buildings, privies, levees, roads, parking lots and other developments (including borrow, disposal, storage and staging areas) outside the stream corridor where possible.

2. Roads to boat ramps, equipment crossings and trails should cross the stream corridor at a right angle to the extent feasible and should be constructed at floodplain grade where possible. Those that cannot be built at floodplain grade should be elevated only enough to facilitate drainage and drying, the shoulders and slopes should be protected from erosion, and culverts should be placed as appropriate.

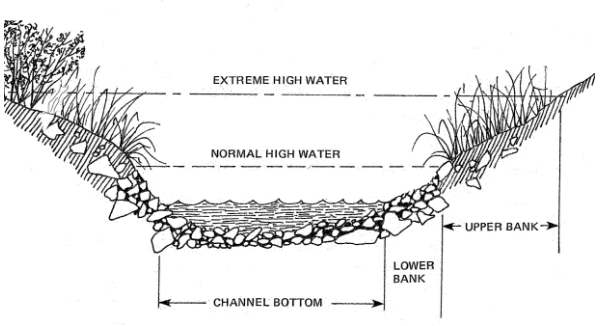
3. Minimize clearing of vegetation during construction and reseed disturbed areas around developments to vegetation as soon as possible following completion of construction activities. Use non-persistent annuals as a nursery crop or a temporary measure until

native vegetation becomes established. Install sediment reduction practices such as sediment fences, retention basins, straw mulch, sod, etc. prior to project start.

4. Stream channel migration tendencies and stability should be considered when construction takes place near the channel. Unless needed because of the nature of the construction project (e.g., boat ramps), locate construction activities away from stream corridors adjacent to the outside bends of stream channels where possible. A D&D Project Engineer should be part of the multidisciplinary team to help design structures that, by necessity, must be located in the stream corridor.

5. Protect stream banks and stream bank vegetation to promote hydraulic stability. Levees and other construction activities should be placed far enough from the stream channel to accommodate adequate vegetated riparian corridors and unblocked high flow channels. Construction projects that must be located within vegetated riparian corridors (boat ramps, water control structures, etc.) shall be designed to minimize impacts to corridors. Development of wetland habitat in association with this type of construction should be considered where feasible and consistent with these guidelines.

Stream Channel Guidelines



The active channel and adjacent high-flow channels convey all non-flood stream flows and a portion of flow during flood events. It includes the bottom and both banks. Determined by precipitation patterns, stream channels have either perennial flow (surface flow continuous throughout the year for streams termed "perennial), intermittent flow (surface flow sporadic but pooled water occurs through all or most of the year for streams termed "intermittent with pools"), or ephemeral flow (surface flow is relatively brief after precipitation events and pooled water is temporary for streams termed "intermittent" or "ephemeral")

Function: Healthy streams have balanced energy--sediment--water interactions, unmodified meander patterns and appropriately sized channels to convey runoff from the watershed without excessive damage to stream banks and beds. Stream channels also provide habitat for water-dependent migratory and resident wildlife, travel corridors for wildlife movement and dispersal of plant species, and critical habitat for many Missouri species of conservation concern

Guidelines

These guidelines apply to the development, management, and improvement of stream channels for fish and wildlife management purposes. However, channel dynamics, configuration and stability are highly dependent on watershed and floodplain conditions. Any change in the

amount of water flowing through a channel (such as from watershed clearing or reforestation, severe and persistent drought or rainy periods that increase or decrease precipitation patterns, construction or breaching of levees, and others) can cause changes in stream channels. Likewise, change in the sediment input to the stream (such as from the increase or reduction of sediment from agricultural fields, sediment-free discharges from dams, and others) also can cause changes in the channel. Finally, increases or decreases in the channel gradient (slope) can change the flow energy potentials of the stream that can manifest in various channel adjustments. For example, channelization steepens channel gradient and increases erosive energy, causing streambed degradation upstream (also known as headcutting) and streambed aggradation (filling or deposition) downstream. Low-water stream crossings without sufficient capacity to pass stream flows decrease the channel gradient and cause streambed aggradation upstream, and often channel erosion downstream.

The interplay of water, sediment and energy among and within the watershed, floodplain and stream channel must be clearly understood before channel improvement structures are installed. A misunderstanding of these complex interactions can result in an unsuccessful project, unstable channel conditions, degradation of stream conditions upstream and/or downstream from the site, excessive erosion and sedimentation, and degraded habitat conditions.

There are two major types of channel improvement structures: structures made from trees, plantings or other vegetation (biotechnical projects); and structures using rock or other permanent physical features (engineering projects).

Stream banks

The following guidelines apply to the management of stream banks on Department lands including capital improvement, maintenance and emergency projects.

1. Determine if stream banks are eroding at an accelerated rate using historical aerial photos or other sources. Stream banks eroding at lesser rates are not considered significant problems and are lower priority.

2. Initiate stream bank improvement projects with a written project plan approved by the Fisheries Regional Supervisor, the regional supervisor of the Division administering the area, and, in the case of structural methods, the Design and Development Project Engineer. The Stream Unit Technical Services Biologist for the area can also help with project planning and design. The project plan should contain an analysis of problem sources upstream and downstream, and recommend the structural measures to be applied. When a recommendation is not apparent, Design and Development Division staff, with the assistance of the Stream Unit Technical Services Biologist, will recommend and design a solution with approval from the administering division and Fisheries staff. When the project is approved for construction, all necessary permits (e.g., Corps of Engineers, Department of Natural Resources, floodplain development) should be

coordinated through Policy Coordination Unit and must be obtained before project implementation.

3. Choose biotechnical approaches to stream bank erosion control (e.g., cedar tree revetments, hardwood revetments, willow staking, or other vegetative methods) as the first alternative in any stream bank erosion project whenever possible. Engineering approaches may be necessary when there is a high-value structure that must be protected, the stream banks exceed 20 feet in height, or the instability of the reach indicates that biotechnical approaches are not likely to succeed.

4. Design all stream bank erosion structures to protect and stabilize the toe of the stream bank. Projects not protecting the stream bank toe will likely fail.

5. Design all stream bank improvement projects to start and stop at a stable point on the stream bank. If a stable starting or stopping point is not available on Department lands, agreement to continue the project to a stable point should be obtained from adjoining landowners. If this is not obtainable, the project should be reconsidered and possibly cancelled. Alternatively, a stable point can be engineered using large rock or riprap.

6. Design all stream bank erosion projects to minimize disturbance of the stream corridor and to include a stream bank and stream corridor revegetation plan. Natural revegetation of stream banks is acceptable providing there is a nearby seed source. If a seed source is not available, stream banks must be planted using native species adapted to stream bank conditions of the region.

7. Inspect all new stream bank erosion projects following each half bank-full or greater discharge. Any needed maintenance should occur as soon as possible and before the next high flow event. The frequency of inspections may diminish as the bank stabilizes.

8. Do not routinely remove stream bank or in-channel vegetation to decrease hydraulic roughness and increase flow. Clearing and snagging of trees or other vegetation on the bank or in the channel often degrades fish habitat and adversely affects other aquatic life.

Instream Habitat

Instream structures are defined as materials placed in or near the stream bed to restore or improve habitat conditions for aquatic fauna. These structures are usually anchored rootwads, boulders, riffle structures or overhead structures such as skyhooks. The following guidelines apply to instream habitat structures on Department lands:

1. Initiate instream habitat improvement projects with a written project plan approved by the Fisheries Regional Supervisor, the regional supervisor of the Division administering the area, and the appropriate Stream Unit Technical Services Biologist. The project plan

should contain an analysis of habitat problems in the reach (including upstream and downstream), and recommend the structural measures to be applied. When a recommendation is not apparent, the Stream Technical Unit will involve Design and Development Division staff as needed to recommend and design a solution (with approval from the administering division and regional Fisheries staff). All necessary permits (e.g., Corps of Engineers, Department of Natural Resources, floodplain development) should be coordinated through Policy Coordination Unit and must be obtained before project implementation.

2. Document that water quality and stream flow are adequate to support aquatic life. Determine that physical habitat quantity or diversity is a limiting factor to aquatic productivity to avoid placing habitat structures where they are not needed.

3. Design all instream habitat plans to take into account bank-full flood conditions. The location and orientation of habitat structures must not adversely affect the stream during high flows.

4. Do not place instream habitat structures in a riffle or a stream section known to be significantly degrading (downcutting), aggrading (filling in with sediment) or otherwise unstable. Placing rootwads, boulders or cedar trees in riffles or downcutting streams could cause the riffle to be eroded or produce scour erosion on the channel bed. Instream structures should not be placed near the mouths of tributaries entering larger streams because they may be covered with sediments, nor should they be placed adjacent to outside, eroding channel bends. Use of habitat structures in high gradient streams must be planned carefully to withstand high flow velocities.

5. If an instream project is proposed in a Natural Area or in critical habitat of rare, threatened or endangered species, prior approval should be obtained from Wildlife Division and/or the MDC Natural Areas Committee.

6. Do not remove or move instream habitat, including log jams and flood-deposited large woody debris, to another location in the stream channel without consulting with the Fisheries Regional Supervisor or Stream Unit Technical Services Biologist and a Design and Development Division Project Engineer to avoid creating additional problems elsewhere.

Other Stream Channel Activities

The following guidelines apply to other activities within stream channels on Department lands, including CI projects, construction/maintenance requests and emergency repairs.

1. Precede all other stream channel projects (e.g., channel width or bottom manipulations for habitat purposes such as adding riffles, removing low water bridges, etc., but not channelization; see #2) with a written project plan approved by the regional supervisor of the Division administering the area, Fisheries Regional Supervisor and the appropriate Stream Unit Technical Services Biologist. The project plan should contain an analysis of stream channel problems in the reach (including upstream and downstream), and recommend the structural measures to be applied. When a recommendation is not apparent, the Stream Technical Unit will involve Design and Development Division staff as needed to recommend and design a solution (with approval from the administering division and regional Fisheries staff). All necessary permits (e.g., Corps of Engineers, Department of Natural Resources, floodplain development) should be coordinated through Policy Coordination Unit and must be obtained before project implementation.

2. Channelization includes stream straightening, digging pilot channels, increasing the size of channels to increase their flow capacity and partial or complete rearrangement or removal of gravel, sand bars, and instream habitat features such as rootwads and submerged trees. Channelization is a very destructive practice and should not be considered on Department lands except in unusual cases. When unusual circumstances dictate consideration of channelization, the following guidelines should be followed very carefully. Channelization of any stream on Department lands may not be undertaken unless previously approved jointly by a Stream Unit Technical Services Biologist and a Design and Development Division Project Engineer. Initiate channelization projects with a written project plan approved by the Fisheries Regional Supervisor, the regional supervisor of the Division administering the area, and the appropriate Stream Unit Technical Services Biologist. The project plan should contain an analysis of stream channel problems in the reach (including upstream and downstream), and recommend the structural measures to be applied. When the solution to a stream channel problem that suggests a channelization recommendation is not apparent, the Stream Technical Unit will involve Design and Development Division staff as needed to recommend and design a solution (with approval from the administering division and regional Fisheries staff). All necessary permits (e.g., Corps of Engineers, Department of Natural Resources, floodplain development) should be coordinated through Policy Coordination Unit and must be obtained before project implementation.

3. Do not block, divert, clear vegetation from or constrict high flow channels (including old abandoned channels). These channels provide important localized flood relief.

4. Operation of heavy equipment in stream channels (other than crossings) must be approved in advance by the Fisheries Regional Supervisor. Projects requiring the use of heavy equipment may include stream improvement structures, instream habitat structures, or water-based developments. Heavy equipment may cross streams at existing stream

crossings or at riffles, but crossings should be restricted to those necessary to quickly finish an improvement project.

5. Design structures, including boat ramps and bank stabilization structures, to avoid a 15% or greater channel constriction, super-critical flows (e.g., sudden flow changes producing standing waves or other hydraulic problems associated with an increase in water level in the vicinity where the flow changes) or the potential for backing up water during a flood. Avoid placing scour structures (e.g., an anchored rootwad) adjacent to the outside bends of stream channels. Avoid placing boat ramps adjacent to inside bends to reduce sedimentation on the ramp.

6. Use bed stabilization structures such as riffle or grade stabilization structures only when stream beds are degrading (downcutting). These structures should be keyed into the bank and bottom, and placed in locations and at elevations where they do not allow significant aggradation (deposition) of sand, silt or gravel upstream.

Sand and Gravel Removal

Instream sand and gravel removal is detrimental to fish and wildlife habitat and should be avoided on Department lands. However, there are instances where sand and gravel removal may be necessary.

Sand and gravel removal (including CI projects, construction/maintenance requests and emergency repairs) is permitted on Department areas under a special use permit from the Fisheries Regional Supervisor and the regional supervisor of the area administering division. The following guidelines apply to sand and gravel removal on Department areas as well as instances where Department roads, trails and/or land is used to gain access to private land for the purpose of dredging sand or gravel. Guidelines apply to all streams meeting the stream definition.

1. The unit responsible for the sand and gravel removal must obtain a 404 permit (U.S. Army Corps of Engineers), 401 water quality certification (DNR), archaeological clearance (DNR) and rare and endangered species clearance (MDC-Wildlife Division) before removal activities can commence. A National Pollution Discharge Elimination System (NPDES) permit (DNR) will also be required for sand/ gravel washing activities. Policy Coordination Unit will coordinate application for these permits.

2. Restrict sand and gravel removal to sand/gravel bars that contain small, unconsolidated materials. Bars that consist of well consolidated or large material or are vegetated and stable should not be disturbed. The appropriate Fisheries Regional Supervisor or Stream Program Coordinator will help with this determination.

3. Sand and gravel removal cannot result in channelization of a stream. Spoil material or gravel cannot be moved or packed on the banks in an attempt to control bank erosion.

4. Conduct gravel washing out of the channel and use settling basins. Discharge from settling basins must meet Missouri water quality standards.

5. Do not remove or wash sand and gravel between March 15th and June 15th to prevent adverse impacts to fish spawning areas.

6. Keep all heavy equipment out of the water and do not remove sand/gravel from below the elevation of the normal water line. Exceptions are permitted with the permission of the Fisheries Regional Supervisor provided that a grade control structure is installed above the mining area and a limit to the amount of sand/gravel removed is established.

7. Crossing streams with vehicles and equipment should be kept to a minimum, restricted to riffles, and be perpendicular to the stream channel.

8. Do not release or dump fuel, oil or other toxic materials into streams.

9. Do not remove sand or gravel from riffles because they provide important features to the stream such as bed and channel stability and quality habitat for aquatic fauna. Sand and gravel removal from riffles also decreases the depth of the upstream pool.

10. Do not pile oversize material in the channel. Streamside stockpiles and oversized material should be promptly removed to an appropriate, non-wetland site outside the stream corridor. These stockpiles should not be placed in such a manner or location as to cause a problem during out-of-bank flooding.

11. Leave the disturbed area contoured similar to the unmodified condition. Oversized material can be used for this shaping, if specified in the 404 permit.

12. Do not remove sand or gravel within 25 feet of riparian vegetation or within 25 feet of the wetted stream channel. Do not excavate below the water line.

13. To minimize adverse impacts to Department lands and waters, managers granting special use permits to landowners to cross MDC lands to access private lands for gravel removal should add conditions to the permit to require that the above MDC sand and gravel dredging guidelines be followed.

Roads and Crossings

The following guidelines apply to roads and crossings on Department lands including construction/development projects, construction/maintenance requests and emergency repairs:

1. Stream crossings are structures designed to allow the movement of people or equipment across streams. Stream crossings include, but are not limited to, bridges, low water crossings and slabs. These structures should not raise the stream bed elevation, constrict

the channel or floodplain or cause stream bank erosion problems. Poorly constructed structures should be replaced, provided that their removal does not further destabilize the stream reach.

2. Design stream crossing structures requiring the temporary or permanent placement of culverts in a stream in such a manner as to allow aquatic organism movement. Maximum flow velocities in the culverts should not exceed 3 feet per second. Culverts should be placed to prevent the aggradation of sand, silt or gravel upstream of the structure. The appropriate Stream Unit Technical Services Biologist, with assistance of a Design and Development Division Project Engineer, will help with the design of these structures.

3. Design stream crossing structures to concentrate flows in the middle of the channel to help prevent erosion of stream banks or crossing approaches. This can often be accomplished by designing crossings oriented at right angles to the channel with a vertical curve (dip) in the middle, or by constructing the crossing in a "V" shaped manner with the point facing upstream.

4. Slab crossings laid at the existing stream bed elevation are preferred. Any bridging structure two feet or higher should be culverted to allow conveyance of normal flows (defined as annual average discharge, or QAA, from USGS flow records) to pass unhindered. It is important to allow normal flows to pass; if an unculverted structure height increases above the streambed, the stream channel is filled upstream and a scour hole/plunge pool develops downstream. The amount of filling upstream and the depth of the plunge pool downstream usually increase as the height of the crossing increases. Excessive downstream scour can cause failure of the structure. The height of the structure or the number and size of the culverts should be increased if merely conveying normal flows will still result in channel filling.

5. Construction, modification or emergency change of stream crossing structures must be approved by the Design and Development Project Engineer, Fisheries Regional Supervisor and regional supervisor of the area administering division prior to installation, modification, repair or maintenance. All appropriate permits must be obtained prior to implementation.

6. Minimize the clearing of streamside trees in road and crossing construction. Always use silt fences or other sediment containment practices when disturbing soil near streams.

7. Plan, locate and construct roads in stream corridors and crossings to minimize sediment delivery to the stream. Roads should be kept at the elevation of the floodplain and stream corridor if possible, and cross streams at right angles. Roads should not be constructed parallel to the stream channel.

8. Stabilize all exposed soil immediately using mulch and grass seed in road construction projects in stream corridors. Temporary roads needed in stream corridors should be built at floodplain elevation, reshaped, mulched and seeded with native species. Use non-

persistent annuals as a nursery crop or temporary measure until native vegetation is established.

9. Design approaches to stream crossing structures with a gentle grade without constricting the floodplain.

Summary

Streams are the product of the land surrounding them, and uplands, floodplains and stream corridors all interact to affect the quality of stream habitat and adjacent terrestrial communities. Department lands contain a reservoir of species, and most conservation lands require active management to sustain habitat for native vegetation, fish, and wildlife. Through the application of these guidelines, the aquatic and terrestrial resources on Department lands will be improved, protected, and restored. This is accomplished by establishing criteria for managers to recognize and address stream problems, and by helping them define desirable conditions that can serve as area management objectives.

These guidelines offer the MDC manager the flexibility to use current, sound, scientifically based management techniques when managing (or offering management recommendations for) Missouri's landscape. MDC resource professionals (regardless of division) have the adaptability needed to effectively manage MDC owned lands and offer sound, scientifically based management recommendations on private lands. If needed, a local "interdisciplinary team" of MDC professionals can seek consensus on management recommendations that vary significantly from the guidelines, on a case-by-case basis. This is especially true when there are site specific or regional variations that need to be taken into account.

These guidelines represent current knowledge about floodplain, riparian corridor, and channel functions and their effects on habitats and long term survival/productivity of stream system flora and fauna. They also allude to gaps in our understanding of the effects of some management practices on streams. The guidelines presented here should be viewed as our current understanding with the recognition that new information will be used to update them. It is the responsibility of the resource manager to consult with technical experts (among MDC staff or elsewhere) and obtain the best science available in order to evaluate trade-offs between techniques when using any technique, anywhere on the landscape (which is synonymous with the definition of a watershed) but especially when working streamside. Meanwhile, these understandings, coupled with reasonable flexibility and a collaborative interdivisional spirit, will result in successful management actions as staff work together on management approaches that improve all resources associated with Missouri's abundant stream systems.

APPENDIX A—Definitions



Aggradation - The process by which stream beds rise in elevation due to the deposition of eroded material such as sand, silt or gravel.



Alluvial soils - Soil eroded from floodplains or adjacent uplands and deposited next to stream channels.



C-level stocking - Stocking levels reflect the amount of utilization of space, sunlight and nutrients at a particular site. C-level stocking is the minimum level at which a forest stand can be considered adequately stocked. Stands at this level contain a sufficient number of trees to occupy the site but allow space for tree growth. This ranges from 450 trees per acre and 22 square feet of basal area for 3-inch average dbh stands to 50 trees per acre and 60 square feet of basal area for 15-inch average dbh stands.



Channelization - Stream channel modifications involving increases in channel capacity (reducing local flooding), removal of obstructions, or relocation of the channel to a different location. These modifications usually result in a shorter, straighter, steeper channel.



Degradation - The process by which stream beds down-cut, incising deeper into the valley bed.



Floodplain - The relatively flat land surface adjacent to an active stream channel that is formed by erosion and sediment deposition during floods. Floodplains can be inundated annually or only during large, infrequent floods, and comprise the above-bank area where floodwater enters to dissipate energy during high flows. Thus, floodplains are characterized by soils and vegetation that developed under the influence of flooding. Floodplains can be geographically located from FEMA (Federal Emergency Management Agency) or NRCS (Natural Resources Conservation Service) 100 year floodplain maps. Floodplains also can be identified by characteristic soils and vegetation where 100 year floodplain maps are not available.



Floodplain scour - Erosion across a floodplain, usually produced by overland flow as floodwaters

travel a more direct route down a valley. Gullies or secondary high flow channels are often produced by floodplain scour.



Gully erosion - Erosion caused by concentrated water flow producing incisions in the soil. Gullies are often a foot or more in depth and more or less remain at the same location (as opposed to rills, which migrate back and forth across a landscape and often are obliterated by cultivation).



High flow channel - A stream channel active only during high water events. A high flow channel is partially or totally at a higher elevation than the main stream channel and serves an important function in providing hydraulic relief during flood events.



Low hydraulic roughness



High hydraulic roughness

Hydraulic roughness - Morphological features (vegetation, topography, geology) causing increased friction for the movement of water. The greater the hydraulic roughness, the slower water will flow at a given site.



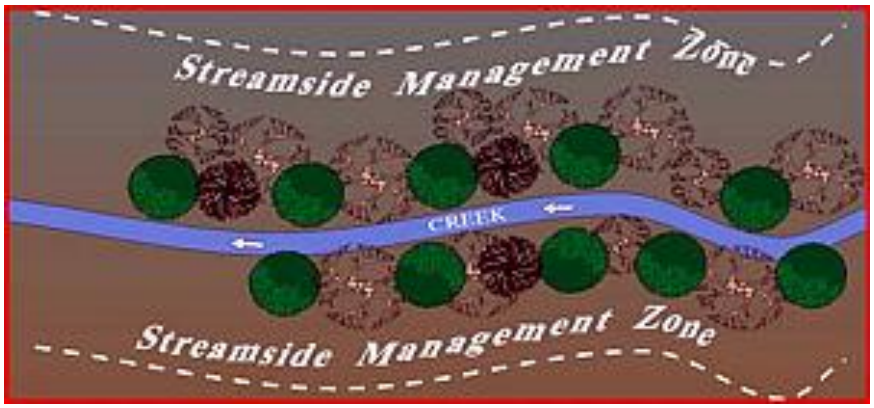
Sheet and rill erosion - The erosion of soil in thin layers, or sheets, from a broad, dispersed area from the action of wind or water.



Stream - For the purpose of these guidelines, a stream is defined as any surface watercourse with defined bed and banks. U.S. Geological Survey (USGS) topographic maps are unreliable in defining small streams. Considerable judgment is required of cartographers to place dashed lines or blue lines on topographic maps to indicate a stream. Soils or valley topography are better indicators of a stream where flow is intermittent and permanent pools are not present. A visual inspection may be required to determine the presence of Order 1 stream characteristics.



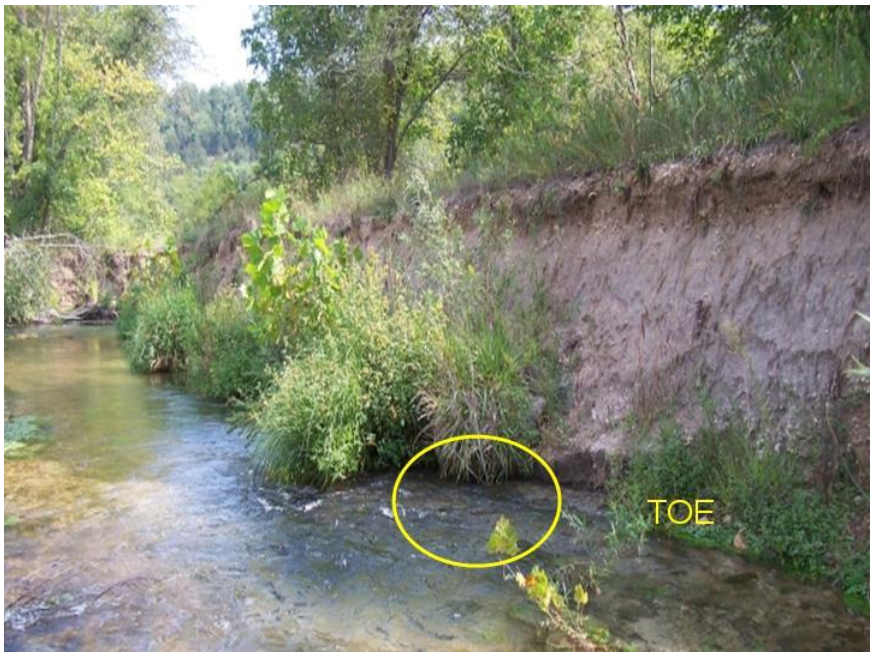
Stream Channel - The bed and both banks of a stream below the top elevation of the bank.



Stream Corridor (Streamside Management Zone—SMZ)- A stream corridor is a designated management zone beginning at the top of the stream bank and extending away from the stream. In this zone, management must first be designed to protect or provide additional benefits to the stream. The stream corridor serves important stream functions including, but not limited to, sediment trapping, use and storage of excessive nutrients, shading of the stream, slowing the velocity of high water, bank stability, flood control, natural wetland development and delivery of organic matter to the stream. Foresters consider this area the forest stand adjacent to the stream where extra precaution is necessary in carrying out forest practices to protect the stream bank and water quality. .

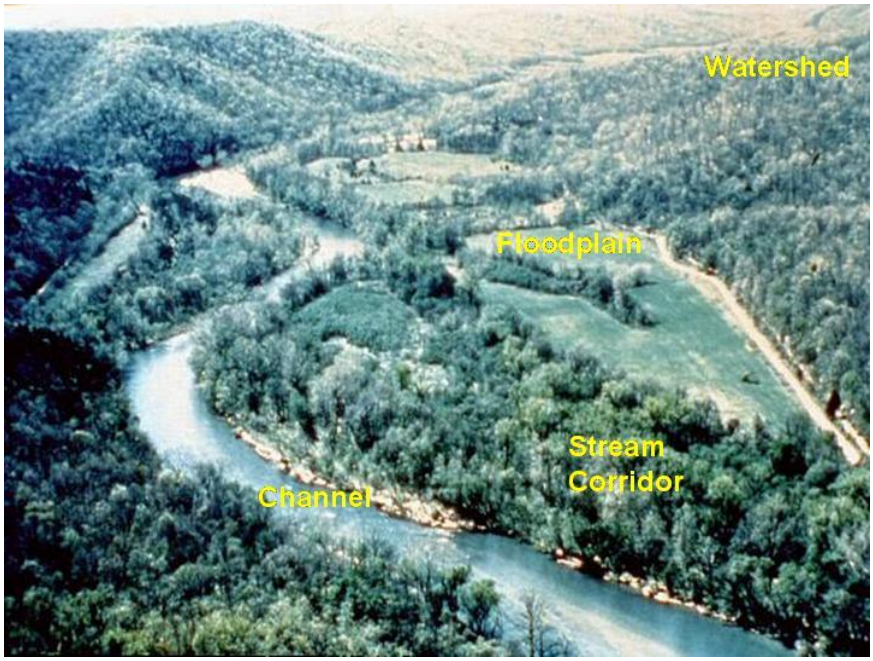


Stream bank stabilization - The process of reducing the erosion rate of an unstable stream bank to establish a more balanced water-sediment-energy condition.



Stream bank toe - The point where the bottom of a stream bank meets the stream bed.

T - The erosion rate at which the amount of soil eroding from a field is equal to the amount of soil produced by natural processes from parent material. In Missouri, this varies but averages approximately 5 tons/acre/year.



Watershed - A watershed is the region or area bounded by a water divide and draining to a watercourse. Watersheds can vary from a few acres to thousands of square miles. For these guidelines, a watershed is defined as the total land area upstream of a given point that contributes runoff to a body of water and includes uplands, floodplains, stream corridors and stream channels.